Air Force Dual Use Science & Technology

Technology Focus Areas
DUS&T Solicitation for FY 2000

GENERAL INFORMATION: The Air Force Dual Use Science and Technology (AF DUS&T) program manager and central point of contact is Mr. Richard Flake (937) 656-9015. Additional information about the AF DUS&T program including the 1999/2000 Competition can be found on the Internet at the following address: www.afrl.af.mil/dualuse/index.htm. Each topic area listed below identifies the technical point of contact through which any technical questions and the white papers should be submitted. All final proposals should be sent to the corresponding Contracting Officer (CO) listed at the end of each topic area.

WHITE PAPER PHASE: To receive feedback on concepts from the technical point of contact, please provide a three (3) to five (5) page White Paper as soon as possible but not later than 30 Mar 99 to the technical point of contact listed on the topic that is of interest. The White Paper should address each or any of the four (4) criteria listed in the solicitation for which feedback is desired. The technical point of contact will provide feedback within twenty days. Feedback will ONLY be value added and WILL NOT provide a recommendation to submit or not to submit a full proposal. In addition, it is NOT necessary to submit a White Paper to participate in the proposal phase of the competition. White Papers can be mailed, faxed or e-mailed to the technical point of contact. The response will be returned in the same fashion as submitted (mailed, faxed or emailed). Provide all of the following information with the white paper submittal: telephone number, fax number and full mailing and emailing addresses. Finally, provide submittals in a twelve- (12) point font.

PROPOSAL PHASE: Detailed instructions for preparation of full technical and cost proposals (due 1400 EDT 29 April 1999) are contained in the Broad Agency Announcement (BAA) www.dtic.mil/dust/baa.htm. Four (4) copies of both the technical and cost proposals are required. Air Force Instructions for Preparing Budgets may be accessed on the internet web site www.afrl.af.mil/dualuse/in

AFFORDABLE SENSORS

00-SN-01

TITLE: SENSORS ENABLING TECHNOLOGIES

OBJECTIVE: Develop affordable, advanced Sensor technology that can be applied to both commercial and military Space and Airborne Systems. These technologies, which range from devices to complete systems, must also have other commercial applications, such as telecommunications, imaging and surveying, and medical.

DESCRIPTION: Air and space sensors are needed to give a complete and timely picture of the battlespace, enable a timely precision response, and enhance the warfighter's survivability. Areas to be focused on: airborne and space-based radars, including advanced antenna designs and low cost digital receivers; active and passive electro-optical systems, including multi-spectral and hyper-spectral sensors and multi-function laser radars; navigation aids, including inertial navigation components and satellite-based global positioning; and, automatic target recognition and sensor data fusion.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $6.6M

Estimated Program Duration: 24 to 36 months

Program Elements: 62204F

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00-SN-02

TITLE: SILICON BASED LWIR THERMAL SENSORS

OBJECTIVE: Develop an all silicon, low power, longwave infrared (LWIR) detector that could be designed to operate at 400K (Kelvin), 300K, or 200K. It would reduce the unit sensor cost by leveraging the silicon technology infrastructure, reducing the system power requirements, and serving multiple Air Force missions and commercial products. DoD applications include imaging for a missile seeker, multiple aircraft sensor 4π-steradian threat warning, and passively cooled thermal imaging from space. Commercial applications include security systems, collision avoidance imaging for automobiles, aircraft landing systems for night and bad weather, and space based imaging for soil characterization and crop analysis.

DESCRIPTION: Uncooled LWIR sensors are available from multiple sources in a 320x240 array format with pixel sizes of 50x50 micron^2, and sensitivity (Noise Equivalent Temperature Difference) of 20 mK using f/1 optics. The sensor technology uses two types of detectors: Pyroelectric and Bolometer, both having comparable sensitivity, neither being silicon based. These sensors are thermally stabilized at room temperature using a thermoelectric cooler to remove the heat generated by sampling the detector. The thermoelectric cooler consumes a majority of the sensor power. Researchers using AFOSR 6.1 funds and DARPA sponsorship have recently developed the theory of operation for a new class of Bolometer, based on thermionic emission. In addition, a thermionic thermal detecting (TTD) element, made from silicon, has been electrically demonstrated that is suitable for 300K operation. Detectors designed for operation at 200K and 400K still need to be demonstrated to meet the above commercial and military requirements. The TTD can then be substituted into a conventional Bolometer multiplexer as a low cost mechanism to demonstrate the sensor. The goal is to develop an uncooled LWIR detector, using silicon technology, that operates at 400K, 300K, and 200K, that is much lower in cost, power, and weight, while being much more reliable and three times more sensitive than current uncooled detectors.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $500K

Estimated Program Duration: 4Yrs

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00-SN-03

TITLE: 2D OPTICAL LOCK-IN IMAGE DETECTION

OBJECTIVE: Develop synchronous image detectors that will provide real-time analysis of low to sub-background optical signals in military and commercial applications. Current optical detectors can be combined with on-chip homodyne or heterodyne electronics to provide a high-speed miniature opto-electronic parallel processing smart sensor array. This new technology in miniaturized parallel optical signal detectors provides substantial processing speed improvements for guided and free space optical communication receivers; for measuring beam aberrations from atmospheric turbulence to correct optical wavefronts; and for performing imaging measurements of frequency shifts to determine surface metrology, structural analysis and motion detection. Such detectors can be used in military systems for detecting non-cooperative and hidden targets. Commercial applications include parallel detection of wavelength division multiplexed optical communication channels and medical imaging through tissue.

DESCRIPTION: Miniaturized high-speed 2D detectors can be provided by designing and constructing an accurate lock-in opto-electronic device for the coherent detection and analysis of weak optical signals and images in background noise. The optical input includes a temporally modulated signal component that may be separated from the noise component by phase-sensitive detection and time-integration. This provides a two dimensional implementation of conventional electronic one-dimensional lock-in or phase sensitive signal detection. With the current technology in optical modulation and detection, the speed of this opto-electronic lock-in device is primarily limited by the electronics used for averaging, control and 2D read-out. This device would have a spatial resolution of 30 microns in arrays of at least 32x32 pixels. It would operate over the wavelength range of 1 to 1.5 microns and provide ability for external control of the coherent reference signal and the averaging time.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $600K

Estimated Program Duration: 36 months

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00-DE-03

TITLE: HIGH SPEED, HIGH DYNAMIC RANGE, FULL WAVE, PHASE RETRIEVAL WAVEFRONT SENSOR

OBJECTIVE: The objective is to build a high speed, high performance wavefront sensor based on a phase retrieval algorithm. One goal is to improve wavefront reconstruction speed (latency) by at least a factor of ten. Another goal is to provide a wavefront reconstruction capability that will operate in high scintillation environments. Such wavefront sensing is required in numerous DOD and commercial applications. DOD applications include ground, airborne, and space laser and imaging systems. Commercial applications include satellite imaging, optical communications systems, astronomy and optical metrology. Improved wavefront sensors can enhance performance in all of the above areas. The Airborne Laser system in particular can benefit from faster, more accurate sensing and wavefront reconstruction.

DESCRIPTION: The goal for this effort is to build and test a wavefront sensor based on a phase retrieval algorithm. The phase retrieval approach holds out the promise for a wavefront sensor and processing algorithm that will deliver a measurement of the full field at pixel level resolutions and at speeds up to twenty times faster than current methods. In addition the technique will offer very high dynamic range and operate in high scintillation environments, unlike current Hartman Wavefront sensors with least squares reconstructors.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $0.4M

ESTIMATED PROGRAM DURATION: 36 months

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00-DE-04

TITLE: DEVELOPMENT OF COMPACT MID-IR SEMICONDUCTOR LASER SOURCES

OBJECTIVE: The objective of the work to be performed is to develop compact mid-IR semiconductor laser sources for applications such as insitu and remote environmental monitoring and detection of chemicals and infrared countermeasures (IRCM). Given the recent advances made in the development of mid-IR lasers, the technology is ready for integration into fieldable systems. With the increasing pressure for industry to monitor its environmental impact, the commercial market for environmental monitoring is tremendous. Military applications are also enormous. Military applications include the need to detect manufacturing plants for chemical weapons, testing and detonation of chemical weapons, and even detecting vehicle fumes to monitor convoy activity and infrared countermeasures.

DESCRIPTION: Recent improvements in semiconductor lasers have made these laser sources practical for use in fieldable systems. Their small size and high efficiency, along with significant improvements in beam quality, mode control, frequency and thermal stability, and output power point to a future in which these lasers will play a significant role in many applications. Recent advances in mid-infrared semiconductor lasers have resulted in higher power levels in the 2 – 5 micron range. Improvements in operating temperature have allowed laser devices to be more compact. This opens up many applications not previously addressed by semiconductor lasers, such as sensing and IRCM.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $1.1M

ESTIMATED PROGRAM DURATION: 24 months

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00-HE-01

TITLE: EMF EXPOSURE DETECTION AND RAPID PREDICTION OF PHYSIOLOGICAL RESPONSES

OBJECTIVES: The warfighter in the Space and Air Force will utilize emerging electromagnetic field (EMF)-emitting technologies, such as the Long Range Dual Band Transportable Radar and Ground-Based Relocatable RF Jammer. Commercial enterprises are developing EMF technologies for scientific, medical, clinical, communication, and residential applications. Present and future applications may include: 1) global communication devices, 2) intraoffice computer networks, 3) security devices, 4) incubators for premature infants, 4) medical imaging, and 5) climate-conditioning systems for homes and space vehicles. A product of potential interest to both military and commercial aviation is an EMF-warmed emergency shelter for aircrews stranded in cold environments or after cold water immersion.

Safe operation of these EMF emitters requires valid techniques to detect high levels of exposure, predict human bioeffects, and establish personnel protection standards. Detecting EMF exposure requires the development of a personnel dosimeter (research being conducted by Dr. Johnathan Kiel, AFRL/HEDB). This is of extreme importance during military deployment and in epidemiology research. Predicting human bioeffects and establishing personnel protection standards for EMF emitters requires knowledge of the amount of energy absorbed by individual organs and the thermoregulatory capacity of specific tissues.

DESCRIPTION: Development of a small portable badge to detect EMF exposure, similar to that used to monitor ionizing radiation exposure, needs to be completed and brought to market. This product needs to have a stable shelf life and be resistant to extreme environmental conditions. Equipment required to "read" the badge needs to be accurate, inexpensive, and portable.

Rapid prediction of human physiological responses to EMF exposure, ranging from 3 KHz to 300 GHz, requires comprehensive computer models. Components of these models include: 1) software to predict the homogeneity or shape of the EMF, in near and far fields, 2) accurate digital anatomical human models, 3) dielectric values for biological and inorganic substances, 4) parallel processing hardware and software to predict localized energy absorption (specific absorption rate), and 5) thermomodeling programs incorporating specific absorption rate values and thermoregulatory responses such as local sweat rates and changes in blood flow, as measured by functional magnetic resonance imaging (MRI), laser Doppler flowmetry, and microspheres. Validation of the model will be performed using electric field and temperature probes, infrared thermography, and diffusion MRI.

Product development will directly address two of the highest priorities established for the International EMF Dosimetry Project at the NATO-sponsored, AFRL/HEDR-organized meeting in Slovenia (October, 1998). These two priorities were to: 1) develop the capabilities to predict localized temperature changes during EMF exposure, and 2) harmonize international EMF exposure standards. The latter will be more feasible due to increased confidence in dosimetry predictions and measurements. This results in smaller uncertainty margins being incorporated into exposure standards. Harmonized EMF exposure standards are essential for the global operation of the Space and Air Force.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $1.65M

ESTIMATED PROGRAM DURATION: 36 Months

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00-ML-07

TITLE: HIGH PERFORMANCE, INTEGRABLE POLYMERIC ELECTRO-OPTIC MODULATORS

OBJECTIVE: To develop polymeric materials and processes for fabricating electro-optic (EO) modulators/switches which can be readily integrated into conventional high-data-rate communication systems in both military and commercial applications. To accomplish this, these modulators/switches must be fully compatible with the high-speed electronics systems in which they are to be inserted in terms of overall size, weight and power, and require no further support capabilities than those involved in the use of the current state-of-the-art electro-optic modulators/switches based on lithium niobate. This further requires that these polymeric EO components possess standardized fiber-optic couplers and low switching voltages on the order of 1 volt.

DESCRIPTION: Quite demanding military applications are emerging that require EO materials to enable the fabrication of specific key building blocks for the next generation of fiber optic systems for satellites and aircraft. These systems are needed to meet the extremely high data-rate requirements for communications and interconnects between satellites (approaching 100 Gbits/sec), to enable advanced data-handling architectures on spacecraft and aircraft (i.e. data buses), to withstand EMP (electro-magnetic pulse) and HPM (high power microwave) attacks against our satellites, and for operation in a space radiation environment. These same materials also enable the photonic control of phased array radar. Precisely the same dual-use technology will enable the fabrication of photonic switches and switch matrices needed for commercial communications and cable TV, a market estimated to be approximately $200 million per year in North America for 1999 and expected to be growing at more than 40% per year for several years thereafter. Polymeric EO materials offer the possibility of modulators/switches with a bandwidth range considerably beyond that of lithium niobate, the active EO material currently in use. Besides the desired bandwidth, polymeric materials also offer lower switching voltages, hardening against the radiation environment of space, and, especially, much lower material and processing costs. Specifically, current lithium niobate modulators cost as much as $2,000 per unit, while polymeric-based modulators should lower that cost by at least one order of magnitude. For these materials to replace lithium niobate in high speed communications systems, however, several hurdles must be overcome. For one, EO polymer materials are still a developing technology which has not yet seen extensive real-world uses. To be practically useful in high data-rate communication systems, these materials must first be made fully compatible with current state-of-the-art high-speed electronic circuitry and be easily coupled to standard fiber-optic links. This imposes size constraints on the proposed devices on the order of 5mm x 5mm and modulation/switching voltage requirements on the order of 1 volt or less. Even better, switching voltages of 0.8 volt or 0.3 volt would allow direct connection of these devices to existing ECL or CML electronic driver circuits, respectively, eliminating the need for expensive RF connectors. These improvements in device parameters are predicated upon improvements in materials properties, including enhanced EO coefficients, increased thermal stability, and reduced optical loss, as well as a standardization of material synthesis and processing techniques. Recent developments in this field indicate that these improvements are all within reach.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $2.1M

ESTIMATED PROGRAM DURATION: 36 months of technical effort

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00-PR-01

TITLE: THIN FILM INFLATABLE CONCENTRATORS AS ANTENNAS

OBJECTIVE: Deployable and rigid antennas for space are currently heavy and cumbersome to inject into orbit. There is a new way to produce antennas for space that are lightweight, packageable, deployable, and *more efficient* than current antennas. The objective of this project is to produce thin film antennas from this new technology that was begun under concentrator work for the Air Force, and test them for use in an environment that will transition into a new product—antennas for satellites, surveillance, and space based radar; then also perform in dual-use mode as a concentrator for laser power beaming or solar thermal propulsion when not being used as an antenna. Commercial uses include but aren't limited to the following: Satellites-power, propulsion, and communications. Military uses include but aren't limited to: communications jamming, surveillance, space based radar, and spaced based laser.

DESCRIPTION: A new means for processing thin film inflatable materials has been introduced, and now needs to be reduced to practice. The process involves introducing metal ions into the thin film polyimide constituents and allowing the metal to precipitate to the top of the film. This material is much better than just coating a thin film polyimide with a metal; there are no etches, and no incontinuities. Therefore, the material is completely conductive and there are no short circuits in the antenna. Also, this process allows for production casting of thin film inflatable antennas on molds that were previously used just for reflectors/concentrators. Ground demonstrations that simulate space operations of the antenna are highly desirable. Space flight quality demonstration/hardware production highly desirable. Technologies must show a mutual benefit for military space systems as well as commercial applications. Multiple awards managed by both AFRL/VSD and AFRL/PRRS are possible under this program. The payoff is that the single process from a polyamic acid to self-metallized CP1 film allows almost 100% reduction in short circuits, 100% reduction in electrostatic discharge (ESD)/charging, and almost 100 % conductivity. Elimination of a second coating process may result in 20% reduction in cost, fabrication time, and complexity. The two-or-more-piece antennas required by the current coating process will be eliminated in favor of a single-piece antenna using the new process. Also, it will significantly increase durability and lifetime of reflective polyimides in space while reducing the cost, because reflectivity/conductivity material is embedded in material.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $2.75M

ESTIMATED PROGRAM DURATION: 24-36 months

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ADVANCED PROPULSION, POWER, AND FUEL EFFIENCY

00-PR-02

TITLE: INTEGRATED LAYERED POWER SOURCE FOR SPACE BASED RADAR

OBJECTIVE: The objective of this effort is to fabricate an integrated layered power source composed of a rechargeable lithium polymer battery and a high efficiency solar cell. The TechSat21 initiative (ARFL/VS) has proposed a unique solution to the space based radar need composed of many small size satellites which communicate by forming a network which mimics a much larger single radar array. An enabling technology for this concept is a solar energy source sized to fit in the space and weight requirements. The concept proposed here would support TechSat21 and many other satellite concepts. The article to be developed consists of a solar cell packaged together with a battery and controller/thermal management forming a "sandwich" or layered single article which generates, stores, and distributes energy to the satellite. The solar cell required for this type of construct is now under development at AFRL/VS and is expected to deliver a 35% efficient cell which will significantly reduce the area needed for power generation. The technology to be investigated here, the lithium-polymer battery, would provide the energy storage medium and the structure for the unit. Based on experiments and analysis done to date, an energy density of 300 to 400 Wh/kg are attainable. In addition, the energy storage needs to function over a broad temperature range from -20 to +70 ^{0}C. Weight reductions and increased run times associated with the high energy density are attractive for reducing launch weight costs and extending mission capability. These features are highly desirable in commercial applications such as space satellite networks, electric vehicle applications, cellular phones and lap top computers. Low cost of manufacturing is as important as light weight.

DESCRIPTION: An integrated layered power source that is retractable offers flexibility in meeting varied power requirements. To accommodate small size and desired low cost, an easily manufactured concept that can be mass-produced must be developed. Strings of these layered cells would be packaged to unfold as the satellite deploys. The technology challenge will be to develop a very high energy density lithium polymer battery that can function over a broad temperature range and demonstrate low self-discharge rates consistent with mission requirements of ten to twenty years. The battery would be integrated with the solar cell from the AFRL/VS effort and electronics based on current high energy density DC/DC converters. The "payload" must be self-regulating (i.e., have its own charge control and thermal management) with bus power delivered by the network of interconnected layered power sources.

ESTIMATED AFRL/PRP FUNDING CONTRIBUTION: $1.1M

ESTIMATED PROGRAM DURATION: 36 months

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00-PR-04

TITLE: HIGH ASPECT RATIO COOLANT CHANNELS (HARCC)

OBJECTIVE: Develop fundamental design tools to reduce the risk of incorporating high aspect ratio coolant channels in rocket engine combustion chambers by: (1) Quantifying the relationship among the cooling circuit parameters of wall temperature, pressure loss and aspect ratio; (2) Developing useful correlations for coolant-side heat transfer coefficient that are functions of aspect ratio; (3) Quantifying the heat transfer enhancement due to flow curvature as a function of aspect ratio; and (4) Providing a rich, experimental data-base of forced convection cooling in straight and curved channels to heat transfer community.

The results from this project will represent significant contributions to the knowledge base of high aspect ratio coolant channels, benefiting such applications as electronics cooling, avionics cooling, thermal energy conversion, wing leading-edge cooling and regeneratively-cooled rocket engines.

DESCRIPTION: The project focuses on quantifying the effects of high aspect ratio coolant channels for the benefit of future liquid rocket engine combustion chambers. High aspect ratio coolant channels (HARCC) have the potential to decrease wall temperature while maintaining or reducing coolant pressure loss. This reduction in wall temperature directly correlates with increased life and reliability of the combustion chamber; similar implications apply for other applications. However, since the relationship among aspect ratio, wall temperature and pressure loss has not been well characterized, thermal engineers have been reluctant, even avoiding, designing combustion chambers with high aspect ratio passages. As such, any benefit to rocket propulsion goes unrealized.

This experimentally-oriented project will test straight and curved rocket-like coolant channels over wide ranges of aspect ratio, Reynolds number and heat flux. Each test channel will be a singular flow passage, rectangular in cross-section, constructed with conducting side walls, heated on one side and extensively instrumented. Instrumentation will be sufficient to measure heat flow into channel, temperature profile in walls and fluid, pressure gradient in cross-section and along flow path and fluid flowrate. The data will yield coolant-side heat transfer correlations, wall temperature/pressure loss trade-off analyses and curvature enhancement factors, all as functions of the channel aspect ratio. The emphasis of this research will be on thoroughly investigating the effect of channel aspect ratio on wall temperature and pressure loss, leading to guidelines for designing coolant circuits. A successful program will not only add to the tools for thermal designers but also provide a fundamental baseline for predicting thermal conditions in a small combustion chamber.

This research effort may be divided into three phases of activity. Phase I involves a thorough analysis and design effort to determine the most appropriate design of the straight and curved channels. Geometric, hydrodynamic and instrumentation aspects should maximize the applicability of the results to rocket propulsion. Elements to be determined include: channel width; range of channel height; aspect ratios; wall thickness; channel material; flow length; heat flux level; heat losses; inlet turbulence intensity; fluid properties; Reynolds number; secondary flows; wall and fluid temperature measurements; wall-fluid temperature difference; and streamwise curvature.

The Phase II effort will focus on conducting forced convection experiments over the range of conditions identified in Phase I for the straight and curved channels. Fabrication of the hardware and assembly/modification of a flow loop are required.

Phase III activities relate to analyzing data and ascertaining influence of aspect ratio on cooling characteristics. Specifically, the final report should address the objectives listed above in a thorough, detailed manner. It should also discuss any further research that is needed to address limitations of the present work.

It is anticipated an additional effort will needed to allow these fundamental results to be applicable to rocket propulsion. One scenario calls for the fabrication of two small combustion chambers, one of which has high aspect ratio coolant channels. Hot-fire data from these extensively instrumented chambers would provide rocket-like conditions to help validate the predictive tools of the fundamental study.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $0.25M

ESTIMATED PROGRAM DURATION: 24 months (for three phases indicated above)

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00-PR-05

TITLE: MITIGATION OF PARTICULATE FORMATION IN ENGINES VIA FUEL ADDITIVES

OBJECTIVE: The objective of this project is to formulate, evaluate and apply chemical additives that will mitigate particulate formation in military and commercial engines. Meeting this objective will enable the sustainment of military readiness, and allow both the military and commercial sectors to meet the air quality standards of the Clean Air Act Amendments (1990) and upcoming amendments to this act.

DESCRIPTION: Increased awareness of the adverse environmental effects of pollutants resulting from combusting fossil fuels has resulted in stringent restrictions on emissions permissible for combustion processes. Efforts to legislate air standards on a global scale are largely the direct result of the rise in emissions of oxides of nitrogen (NO_X), carbon monoxide (CO), and unburned hydrocarbons (UHC). More recent efforts to improve air standards have begun to address additional emissions such as particulates. The National Ambient Air Quality Standards have a health-based regulation for particulate matter as it is recognized that airborne particles pose both health and environmental risks. Moreover, particulate (soot) formation leads to increased engine maintenance costs.

The United States military consumes between 4 and 5 billion gallons of jet fuel per year. The level of emissions from military engines corresponds roughly to $5x10^{24}$ particles per year with an average size of 50 nm diameter and an average density of 2 g/cm^3 [1]. The goal of the project is to develop technology to reduce the total particulate emissions from military gas engines by 50%. The proposed technology will also apply to commercial aircraft and perhaps other combustion sources such as power generation gas turbine engines, ground support equipment and automobiles.

Emissions reduction is a challenging endeavor, since it often conflicts with concurrent performance improvements in mobile and stationary combustion systems. It is desired to mitigate particulate formation without compromising on performance. The control of undesirable emissions is intrinsically coupled with decreased pyrolytic deposition [2,3] and increased fuel reactivity [4]. Fuel additives currently being developed to reduce particulate emissions in diesel operate on this principle. Under this proposed project it is desired to evaluate the ability of fuel additives to mitigate particulate formation in jet fuels. Initially, the additives will be evaluated in laboratory rigs. An industry/government team will assess potential additives and determine a test matrix. Ultimately, it is highly desirable to evaluate the effectiveness of the technology in field tests. A critical measure of merit for potential additives will be affordability.

[1].Howard, R. P., et al., "Experimental Characterization of Gas Turbine Emissions at Simulated Flight Altitude Conditions," AEDC-TR-96-3, September 1996.
[2]. Maurice, L.Q., Edwards, J.T. and Griffiths, J.F., and, "Liquid Hydrocarbon Fuels for Hypersonic Propulsion," AIAA Progress in Aeronautics and Astronautics, S.N.B. Murthy and E.T. Curran, Editors, 1998.
[3]. Maurice, L.Q., Striebich, R.C. and Edwards, T. "The Analogy of Cyclic Compound Formation in the Gas-Phase and Supercritical Fuel Systems of Hydrocarbon Fueled High Speed Vehicles," ACS Petroleum Chemistry Division Preprints, Vol. 43(3), pp. 423-427, 1998.
[4]. Aradi, A.A. and Ryan, T.W., "Cetane Effect on Diesel Ignition Delay Times Measured in a Constant Volume Combustion Apparatus," SAE Technical Paper 952352, October 1995.

ESTIMATED PROGRAM DURATION: 28-32 months

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $0.55M

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00-PR-06

TITLE: LIGHT-WEIGHT, HIGH-STRENGTH POLYMERIC MATERIALS FOR PROPULSION AND COMMERCIAL APPLICATIONS COMBINING BOTH REVOLUTIONARY SYNTHETIC AND PROCESSING NANOTECHNOLOGY.

OBJECTIVE: To develop new high-performance materials with a 40% decrease in weight, greater than four times increase in strength, and dual performance e.g., light weight and increased ballistic resistance clothing and transparencies). The research will combine known Polyhedral Oligomeric Silsesquioxane (POSS) nanotechnology developed by the Air Force Research Laboratory with new processing technology for nanospheres particle formation to further increase the strength while also reducing the weight of the fabricated material. Current propulsion needs include jet canopies, radomes, structural insulation and housing for jet engines. Commercial applications include airplane insulation, lenses (optical/contact), medical supplies, and plastic automobile parts.

DESCRIPTION: POSS nanotechnology, developed by the Air Force Research Laboratory, has gained increasing attention due to the recent surge of the nanotechnology field and the significant reported property enhancements through POSS incorporation into traditional organic polymers. POSS containing polymers have been shown to have increased use temperatures and oxidation resistance, reduced flammability and ablative properties, and increased oxygen permeability while imparting an increased free volume (i.e., decreased density) from spatial arrangements of the 15Å diameter cages. This nanotechnology has been incorporated into a variety of polymers (styryl, norbornyl, acrylic, epoxy, and urethane), and it is now vital to work with an industrial source in developing high-performance materials using advanced fabrication/processing techniques. The research effort will involve an iterative process of studying the combination of varying POSS polymers and nanoprocessing for optimum polymer performance/control. Current payoffs from POSS technology include up to a 300% increase in glass transition, 20% decrease in density, and 400% increase in strength. While nanoprocessing has been shown to be capable of up to a 200% increase in glass transition and a 400% increase in strength or 200% decrease in density. The developed technologies will have a mutual benefit for both military (rocket and space) and commercial applications. This program is expected to be highly successful and launch the next generation of plastics technology to the forefront of high-performance materials.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $1M

ESTIMATED PROGRAM DURATION: 36 months

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00-PR-07

TITLE: TEMPERATURE AND CHEMICAL SENSOR FOR HIGH PRESSURE TURBINE INLET

OBJECTIVE: To develop sensors for temperature and/or chemical species sensing for gas turbine engines. These sensors will allow active combustor control, active control of turbine cooling, and vastly enhanced engine health monitoring. This can lead to significant improvements in engine durability and fuel economy. All future military turbine engines will benefit from an improvement in the efficiency and durability of combustor and turbine components. High horsepower output at high efficiency will reduce engine size and improve fuel consumption. Reduction in engine size allows for a reduced weapon system size, cost, weight and can improve survivability, reliability and operability. Temperature and environmental monitoring will allow for optimization, and active control of the engine flows, enabling significant benefits in thrust performance by cooling and weight reduction. Commercial aircraft will benefit form smaller more fuel-efficient engines. Low cost of ownership and operability is a prime factor in commercial systems. Temperature and environmental monitoring, control and optimization will enable quantifiable improvements in pollution prevention, weight reduction, cost and life.

DESCRIPTION: Prototypical development and demonstration of advanced environmental and temperature sensors are needed to support the next generation of high temperature, low fuel consumption military and commercial gas turbine engines. In order to provide the high horsepower output with improved efficiency and fuel economy, the combustors and turbines for these engines will need to meet a variety of new operational conditions. In order to optimize the combustion process, aerodynamic design, and cooling technology to achieve these goals, real time, accurate temperature sensing and chemical sensing of the combustor/turbine flowpath is required. Particular emphasis will be placed on temperature and chemical species sensing devices that can accurately survey gas-path flows at the high temperatures (up to 4000^0F) and high pressures (20 to 50 atm) of advanced gas turbine hot sections while tolerating increased temperatures and pressures of cooling flows. Industry and the DUAP program will develop the feasibility, prototype design, and fabrication for these sensors. Active ongoing partnerships with industry in the areas of basic research, modeling and developmental work will facilitate a clear path to disseminate and insert this technology into future products such as DoD's Joint Strike Fighter and NASA's Advanced Subsonic Initiative Programs.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $0.9M

ESTIMATED PROGRAM DURATION: 24- 36 Months

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00-VA-03

TITLE: TRANSATMOSPHERIC VEHICLE TECHNOLOGY

OBJECTIVE: Demonstrate affordable and operable aerospace vehicle technologies for next generation high speed systems. High speed systems such as the Space Operations Vehicle can provide the seamless aerospace operations envisioned by the Global Engagement Strategy and would be an important adjunct to the Expeditionary Aerospace Force. The technologies required by these military systems provide numerous enhancing opportunities for civilian systems such as the NASA Reusable Launch Vehicle and other commercially driven space access vehicles.

DESCRIPTION: The technologies available today in electric actuation, thermal protection systems, thermal management systems, cryogenic structures, vehicle management systems, and design and analysis tools are insufficient to deliver an affordable vehicle that can be operated at the tempo required for an effective military system. Advances in electric actuation are required to enable the elimination of hydraulic fluids from these vehicles and the attendant maintenance burden. Higher energy densities and improved actuation response are critical needs to be met. Thermal protection systems are heavy, require frequent refurbishment or replacement, and are expensive to acquire. Lighter weight, longer life concepts must be developed. These concepts should eliminate the need for waterproofing such as is done on the Space Shuttle, require little or no inspection (beyond visual) in the field, and be less expensive than those under development within the X-33 program. High temperature cryogenic tanks can reduce and eliminate high temperature insulation and thermal protection systems which will lower weight. Polyimide, titanium, or ceramic composite are potential candidate high temperature tank concepts. Compatibility with liquid oxygen, liquid hydrogen, or peroxide will have to be established. Photonic vehicle management systems will also offer improvements to the system. Coupled with health monitoring/prognostics these systems will allow rapid vehicle turnaround. Finally, design and analysis tools which can rapidly develop concepts, evaluate technology implications, and are more accurate would be beneficial. Proposals in any of these areas would be highly desirable.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $1.8M

ESTIMATED PROGRAM DURATION: 30 Months

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INFORMATION AND COMMUNICATIONS SYSTEMS

00-DE-01

TITLE: ADVANCED TRACKING SYSTEM

OBJECTIVE: An advanced image-based tracking and control system is sought that takes advantage of new state of the art tracking algorithms such as Extended Kalman Filters (EKF). Past tracking systems developed by industry and the government have been very limited in their capability to handle computationally intensive algorithms. However, simulation studies have demonstrated that algorithms such as EKF methods show promise at increasing the jitter performance of tracking systems. Potential commercial applications range from power line insulator damage detection to TV news helicopter systems.

DESCRIPTION: The desired goal for the product is an EKF tracking system that can process track data at 1700 frames per second using a 128 by 128 Dalsa camera interface. Emphasis on this project will be on demonstrating the track processor capability at the desired frame rates. It is envisioned that the system will be tested at the ABL-ACT test facility at North Oscura Peak, White Sands Missile Range.

ESIMTATED FEDERAL FUNDING CONTRIBUTION: $0.35M

ESTIMATED PROGRAM DURATION: 36 Months

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00-DE-02

TITLE: USER FRIENDLY OPTICAL PROPAGATION SIMULATION PACKAGE

OBJECTIVE: Create a user friendly, universal wave optics propagation paradigm that will allow technically sophisticated individuals to create complex wave optics simulations of complicated systems. Codes capable of simulating such systems are generally single user codes with a steep learning curve to their operation. Capturing the essence of such simulation technology in a modular user friendly plug and play environment will allow propagation physicists, control engineers, and others to rapidly apply their knowledge in a sophisticated propagation paradigm without being dependent on those few individuals who currently are the keepers of the single user codes. This will enhance DOD's ability to evaluate, innovate and perform rapid simulation prototyping on systems such as ground, space, and airborne laser weapons and imaging systems. In addition a commercial version will find ready usability in the astronomical community, commercial imaging and laser communication systems which require light propagation through an aberrating media.

DESCRIPTION: The desired goal for this product is a well documented, user friendly, wave optics propagation simulation package with a graphical user interface. The simulation technology will work across several platforms and operating systems. It will readily interface with MATLAB as a data analysis paradigm. It will leverage a $700K AFRL/DEBA investment in a C++/JAVA code, known as ABLSim, into a viable commercial product for sale to the wider optical community as well as make the wave optics propagation investigation accessible to a wider range of DOD researchers.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $0.26M

ESTIMATED PROGRAM DURATION: 36 months

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00-VS-01

TITLE: ADVANCED ALGORITHMS FOR EXPLOITATION OF SPACE-BASED IMAGERY

OBJECTIVE: The objective is to develop algorithms to optimize detection, identification, and tracking of targets for materials identification and for identification and quantification of atmospheric constituents and effluents. The algorithms and processing techniques developed under this effort will be useful in military systems requiring autonomous stand-off detection under stressing conditions of sensor clutter induced by scene structure, the data-collection process, and spectral interferences. The algorithms and techniques will also be useful for commercial applications involving autonomous detection under similar conditions of scene-induced and sensor-induced clutter and noise and spectral interferences.

DESCRIPTION: The Air Force Research Laboratory's Background Clutter Mitigation Branch (AFRL/VSBM) is interested in innovative techniques for the mitigation of clutter effects in an effective and computationally efficient manner for optimum search, detection, and tracking performance of space-based optical (ultraviolet/visible/infrared) systems. Mitigation requires advanced algorithms based upon spatial, temporal, and spectral techniques. While many (individual) techniques exist, some do not fully exploit all possible observables, and others have not been properly evaluated for optimum utility at the system level, nor have they been systematically combined to assess the potential benefits of concatenating algorithms to improve detection probabilities and reduce false-alarm rates. Proposals may include, but are not limited to, the following areas: (1) Conduct analyses, using real data, to identify the classes of algorithms for clutter-mitigation and contrast-enhancement techniques needed to (a) optimize target detection, search, and track capabilities in structured environments, (b) identify materials, and (c) identify and quantify atmospheric constituents and effluents; (2) Compare and contrast the candidate algorithms, and provide a suite of preliminary algorithms suitable for testing with experimental and simulated data; (3) Perform detailed analyses and demonstrate the efficacy and effectiveness of the algorithms; and (4) Develop and demonstrate an automated, near-real-time processing system using real-world data sets.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $0.35M
ESTIMATED PROGRAM DURATION: 24 months

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WEAPONS SYSTEMS SUSTAINMENT

00-ML-01

TITLE: DEVELOPMENT OF GAMMA TITANIUM ALUMINIDE (γ-TIAL) SHEET AS A THERMAL PROTECTION STRUCTURE (TPS)

OBJECTIVE: The objective of this program is to develop gamma titanium aluminide sheet for thermal protection structure applications for launch vehicles. The gamma sheet should be able to operate for more than 500 hours at 800 ^{0}C and for a shorter period of time, approximately 10 to 20 hours at 1000 ^{0}C without the need for thermal barrier coatings. A second objective of the program would be to improve the current limit of production size. Dimensions larger than 2'x 5' thickness less than 40 mils would be required. The objective of the program would include demonstration of formability, joining/ diffusion bonding and verification of mechanical properties that are required for thermal protection structure applications for reusable launch vehicles. Technology developed in the present program for military space vehicles, could be applied directly to commercial sector. A number of potential commercial customers exist both in the arena of reusable launch vehicles and satellite launches and also in the turbine industry. The commercial turbine industry is actively seeking materials such as gamma titanium aluminide sheet for turbine engine nozzles that will not only lower in cost but also lighter, stiffer and more reliable than the presently available superalloys.

DESCRIPTION: One way to effectively increase the performance of future space vehicles in the heavy launch arena is by employing low-density high-stiffness thin metallic structure for thermal protection. While many of the superalloys provide the required temperature capability they fall short both in weight and formability categories. Gamma titanium aluminides not only possess the attributes of high stiffness and low density but can also be produced in sheet form in gage thickness of 1 mm, as recently demonstrated for alloys Ti-48Al-2Cr and Ti-47Al-2Cr-2Nb-0.2B. Therefore, gamma aluminides are an ideal choice for thermal protection structure application. Limited testing of available gamma titanium aluminide sheet also suggests that the presently available sheet product can withstand up to 500 hours at 760 ^{0}C (1400 F) and up to 50 hours at 900 ^{0}C (1652 F). However the use of gamma sheet as thermal protection structure will require not only efficient production of the material in sheet form in a reproducible manner, but also superplastic forming capability, joining and the ability to withstand high temperatures under aerodynamic, fatigue and acoustic fatigue conditions will have to be demonstrated. The effective implementation of gamma titanium aluminide sheet as a thermal protection structure to space vehicles can potentially be limited by a number of factors such as (1) the ability of the sheet to withstand high temperatures over a prolonged period, (2) manufacture of the sheet in widths larger than the currently available dimensions, (3) forming of corrugated structure, (4) joining of corrugated structure to face sheets and the (4) manufacture of honeycomb structure. Although some of these issues have been overcome to a certain degree on limited amounts of material, further improvement and confidence in the technology is required for successful implementation of the gamma aluminide to thermal protection applications under aerodynamic, cyclic and acoustic fatigue loading. The aim of this program would be to address all of the above issues and deliver a viable technology to meet the US Air Force needs in the space launch arena.

ESTIMATED FEDERAL FUNDING: $2.35M

ESTIMATED PROGRAM DURATION: 48-60 months

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00-ML-02

TITLE: NANO-ALUMINUM ALLOYS TECHNOLOGY FOR SPACE LAUNCH

OBJECTIVE: The objective of this program is to further develop light weight high strength nano-crystalline aluminum alloys for use as impellers in fuel and oxidizer pumps and as liquid hydrogen carrying tubes. The development of these aluminum alloys will enable to meet integrated high performance rocket propulsion technology (IHPRPT) requirements of increasing thrust to weight ratio. A number of nano-aluminum alloys are currently being developed. Almost all of these alloys require further improvement in processing to optimize mechanical properties required for impeller applications in liquid hydrogen atmosphere. Furthermore the liquid hydrogen carrying tubes will require isotropic properties. Nano aluminum alloys developed in this program can be used by commercial space launch sector of the industry for both satellite launch and deep space exploration.

DESCRIPTION: Currently titanium alloy Ti-5-2.5 is being used as an impeller material in the turbo machinery operating in liquid hydrogen atmosphere. While titanium alloys, in general, offer many advantages such as high strength and stiffness, low density and high blade tip speed some of the associated disadvantages are poor machinability characteristics, high cost and susceptiblity to hydrogen embrittlement. One way to overcome these issues without compromising the performance would be to replace the currently used Ti alloy with an aluminum alloy that will not only provide equivalent or higher specific strength at cryogenic temperatures but also cost less, will be easier to machine, and immune to hydrogen embrittlement. Currently novel aluminum alloys are being produced through cryo milling and spray forming techniques which can incorporate alloying elements that can impart low density and high strength and toughness to the alloy at cryogenic temperatures. Preliminary properties of these alloys suggest that some of these alloys may rank high as potential candidates for impeller applications for turbo machinery in liquid hydrogen atmosphere. Cryomilling and spray forming are two of the technologies that are being currently used to incorporate alloying elements into aluminum that will provide low density, high strength at room and cryogenic temperatures and high fatigue limit in liquid hydrogen atmosphere. However in order for these Al alloys to be used in rocket motor applications the main issues that need to be overcome are extrudability, improvement of ductility, isotropic properties and fatigue crack growth resistance. Process optimization has to be performed to maximize the properties required for application in space launch.

ESTIMATED FEDERAL FUNDING: $0.45M

ESTIMATED PROGRAM DURATION: 24-36 months

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00-ML-04

TITLE: THERMAL CONTROL SURFACE MATERIALS FOR SPACE APPLICATIONS

OBJECTIVE: To develop innovative thermal control surface material systems for revolutionary new concepts in satellite thermal management as high payoff alternatives to traditional coating or optical solar reflector systems. These technologies will enable new spacecraft concepts to be integrated in future space systems. The commercial use of these high performance thermal control surface materials extends to all satellite configurations.

DESCRIPTION: Thermal control surface materials are required to regulate the temperature of spacecraft systems. Limitations exist within current state of the art thermal control surface materials (thermal control surface materials and optical solar reflectors). These limitations include: insufficiently low beginning of life solar absorbtance, insufficiently high thermal emittance, poor space stability (UV, electron, proton, vacuum, atomic oxygen), poor durability and handleability, poor adherence to substrates, poor cleanability, insufficient flexibility, expensive, insufficient or uncertain supply, poor reproducibility, difficult application, insufficient conductivity, poor thermal cycling behavior, excessive weight, and EPA regulations and restrictions. Past programs have attempted to address some of these issues with partial success. However, no significant technology advancements have been established. New requirements for thermal control management will be necessary for new spacecraft concepts. These concepts (and some issues) include: all composite structures, small high thermal density spacecraft, inflatable or membrane structures, and optically switchable thermal control surface material systems.

Development of new and innovative thermal management concepts are needed for current and future military and commercial space system use. Technologies that hold promise for revolutionary advancements in thermal management include but are not limited to: thin film technologies, polymer film technologies, sol-gel technologies, rugate filter technologies, as well as improved application methods. The focus of this materials development program is on innovative coating technologies applied to systems that include bonded optical solar reflectors, integral optical solar reflectors, film/membrane concepts, integral structural concepts, and other innovative concepts.

Space environment simulation testing in a mid to high earth orbit (no atomic oxygen) will be supplied as government furnished testing. All other necessary testing will be provided by the contractor. Successful material concepts will be scaled up and transition to the potential users in a future program. Technologies must show a mutual benefit for military space systems as well as commercial applications.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $1.75M
ESTIMATED PROGRAM DURATION: 24 - 36 months

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00-ML-05

TITLE:CERAMIC COMPOSITE DEVELOPMENT FOR LIGHTWEIGHT, DURABLE THERMAL PROTECTION SYSTEMS

OBJECTIVE: Develop and characterize ceramic composites for durable, maintainable, reusable space re-entry vehicle thermal protection systems. In both the commercial launch and military launch and operations arenas, the need for routine, affordable access to space via reusable aerospace vehicles requires development of improved thermal protection systems. In the commercial arena this will translate into lower support costs and improved reusability. For military systems an additional driver is the rapid turn around desired for aircraft-like operations.

DESCRIPTION: New approaches and materials for thermal protection systems (TPS) that are lightweight, durable, supportable, and more affordable are necessary for next generation space systems. Ceramic matrix composites (CMCs) are an emerging material class that may be able to satisfy these requirements. Key issues for TPS include insulation efficiency, surface properties, structural durability (acoustic fatigue resistance, erosion and impact resistance, creep), environmental stability, weight, inspectability, design (including attachments and integration with structures or tanks), producibility for coverage of large areas, and life prediction. TPS material and design concepts are required which increase the life of the TPS, decrease the cost and manufacturing time, reduce the part count, reduce supportability requirements, reduce the weight, and eliminate the need for waterproofing. These materials and design concepts will support emerging Air Force systems such as the Space Operations Vehicle (SOV) and Space Maneuverable Vehicle (SMV), as well as commercial launch systems. The program tasks should include selection of one or more candidate materials/structures and iterative fabrication, testing, and analysis of increasingly complex coupons and subelements to optimize the approach. A representative subcomponent should be fabricated and rig tested to validate material capability. In parallel with the materials optimization, repair techniques should be developed, demonstrated, and validated.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $1.15M

ESTIMATED PROGRAM DURATION: 30-36 months

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00-ML-06

TITLE:DESIGN AND DEVELOPMENT OF CERAMIC MATRIX COMPOSITES FOR HIGH DURABILITY HOT AIRCRAFT STRUCTURES

OBJECTIVE: The objective is to design, develop, and demonstrate ceramic matrix composites (CMCs) for hot aircraft structures with improved durability, maintainability, and supportability. The military benefit associated with this technology can be described in terms of the objectives listed above or in terms of the results of the materials improvements: improved aircraft reliability and survivability and reduced support and operational costs. Commercial applications include exhaust components for durability enhancement and noise suppression in developing supersonic aircraft (e.g. high speed civil transport, supersonic business jet), as well as high durability thermal and/or acoustic insulation for severe environment industrial processes where erosion and thermal shock rapidly destroy conventional metals and monolithic ceramics.

DESCRIPTION: New materials and improved designs for hot structures that are more durable, maintainable and supportable are required for next generation military aircraft. CMCs offer the potential for improvements in these areas plus reduced weight and enhanced low observables compatibility. Key issues for hot aircraft structures include thermal durability (temperature capability, insulation and/or cooling efficiency, environmental stability, moisture resistance), structural durability (erosion/impact resistance, acoustic fatigue resistance), weight, inspectability, repair and replacement, component design including attachments to dissimilar materials, and life prediction. Materials, processes, and design concepts are required which increase the life of the components, decrease the cost and manufacturing time, simplify repair and replacement, and reduce the weight. These materials and design concepts will support both existing and future military air vehicles. Examples of hot structures include exhaust washed decks, leading and trailing edges, nozzles, inlet ducts, fins, exhaust ducts, mixers, suppressors, and afterburner liners. The program tasks should include selection of one or more candidate materials/structures and iterative fabrication, testing, and analysis of increasingly complex coupons and subelements to optimize the material selection and design approach. A representative subcomponent should be fabricated and rig or engine tested to validate material capability. In parallel with the materials optimization, repair techniques should be developed, demonstrated, and validated via realistic testing of a repaired subcomponent.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $1.15M

ESTIMATED PROGRAM DURATION: 28-36 months

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00-MN-01

TITLE: COMPOSITIONAL DEVELOPMENT OF A LOW COST HIGH STRENGTH, HIGH FRACTURE TOUGHNESS, NON COBALT STEEL.

OBJECTIVE: The objective of this effort is to develop a revolutionary low alloy steel that possesses higher strength and fracture toughness than is currently available with low alloy steels. The effort will examine composition, microstructural development, and purity while producing a low cost steel. The following specific areas will be undertaken:

- Reduce nickel content and delete cobalt to reduced cost.
- Reduce carbon to reduce welding problems.
- Evaluate processes for and effects of reducing sulfur and phosphorus.
- Develop heat treatment processes that maximize strength and fracture toughness.
- Investigate alloy doping with rare earth elements for tying up sulfur while improving mechanical properties.
- Obtain 260ksi Ultimate Tensile Strength and 230ksi Yield Strength minimally. Obtain 34 ft-lbs Charpy Impact Strength minimally.

DESCRIPTION: New and innovative concepts, processes and materials are required to develop high strength, low cost steels that will have a high commercialization potential. Current methods for improving strength and fracture toughness are generally limited to reduction of sulfur content and adding substantial concentrations of cobalt and nickel. Using these concepts, significant material property improvements have been realized, however, the cost of steel up 6-10 times over that of previously used material. Now that it is known that higher performance materials can be obtained, processes must be developed that will minimize cost while maintaining the desired characteristics. Military application for high strength steel is driven by the need to defeat increasingly hardened threats with more affordable munitions. Areas of process improvement include quality control, heat treatment, mechanical forming processes, reduction of inclusions that cause embrittlement, and development of microstructures that improve strength in concert with fracture toughness. Military uses include bombs, penetrators, submunitions, warheads, projectiles, fuze assemblies, aircraft structures, etc. Commercialization uses include higher performance and lighter weight car and truck frames, commercial aircraft structural components, bridge structures, etc.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $0.15M

ESTIMATED PROGRAM DURATION: 2 years (Oct 1999 to Sep 2001)

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00-PR-03

TITLE: FLEXIBLE FULL AUTHORITY DIGITAL ELECTRONIC CONTROL (FADEC)

OBJECTIVE: To develop engine control technologies that take maximum advantage of the emerging de facto requirement to use commercial off-the-shelf (COTS) electronics in military applications. A flexible, modular full authority digital electronic control (FADEC) with COTS parts has the potential to significantly reduce both recurring and nonrecurring costs for both military and commercial aircraft engines. Control functions are quite similar from engine to engine, making possible the development of common control circuits or modules with multi-engine applicability. A manufacturer with multiple engine development programs underway can then share development costs across those efforts. Production costs are reduced not only by the transition from Mil Spec to commercial parts, but also by the economies of scale obtained through large procurement of identical parts for different programs. A modular, "designed for obsolescence" architecture will also enable reduced support costs through provisions for simple, plug-in upgrades when key electronic parts go out of production later in the life cycle of the engine. With the rapid advancements seen in the electronics industry, obsolescence issues can arise 4-5 times in the life of an engine. The dual-use nature of these technologies is a natural fall-out of the push by all engine manufacturers to use the same advanced technologies in their commercial and military engines.

DESCRIPTION: Recent Department of Defense (DoD) acquisition reform initiatives designed to enable the military to take advantage of commercial technology advancements have created new challenges for certain niche applications with demanding environmental requirements, e.g., aircraft engine control. COTS electronics generally have higher performance and cost less than the Mil Spec parts traditionally used for engine control, but their packaging is not compatible with the unique FADEC board designs that must withstand much higher vibration and temperature levels than found in the typical desktop computing application. New approaches to packaging and thermal management are required to enable the use of the latest commercial integrated circuit (IC) technology without sacrificing the cost advantage that motivated the DoD's move to COTS devices and systems. Highly integrated commercial ICs are also the key to implementing a flexible, modular FADEC architecture, and with it the cost advantages described above, in the volume-constrained engine control application. Proof-of-concept demonstrations of a control module or modules utilizing COTS electronics and capable of full-life operation in an engine environment are highly desirable. Technologies must show a mutual benefit for commercial and military engine control systems.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $0.75M

ESTIMATED PROGRAM DURATION: 24-36 months

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00-VA-01

TITLE: SURVIVABILITY OF TRANSPORT AIRCRAFT TO EMERGING MISSILE THREATS

OBJECTIVE: Develop efficient vulnerability reduction techniques for military and civil aircraft exposed to the shoulder-launched Man Portable Air Defense System (MANPADS) missile threat. Optimize transport aircraft survivability through the integration of vulnerability and susceptibility reduction methodologies. Identify the likely success of leading-candidate concepts through modeling and simulation. Generate acceptance of proposed survivability solutions within the military and commercial aircraft communities.

DESCRIPTION: Vulnerability reduction techniques are needed to insure the survivability of military and civil transport aircraft engaged by MANPADS missile threats. The MANPADS missile is a highly effective weapon proliferated worldwide. Typically containing an IR seeker, the missile offers little opportunity for a warning before impact. Impacts are often lethal. Examples of lethality include 1) the Afghan mujahedeen killing of 269 Soviet aircraft with 340 such missiles, 2) Desert Storm evidence that IR missiles produced 56% of the kills and 79% of the Allied aircraft damaged, and 3) civil aircraft experiencing a 70% probability of kill given a MANPADS hit. Such high kill ratios are unacceptable and require immediate solutions. Recent military engagements, such as Desert Fox, demonstrate curtailment of daytime operations as a result of the MANPADS threat. Civil aircraft remain virtual "sitting ducks" to terrorists. Bin-Laden is reported to have acquired 20 Stinger missiles and quantities of Russian-made MANPADS. Delaying solutions may prove catastrophic.

Whereas susceptibility reduction (hit avoidance) should be regarded as the primary means of aircraft defense, optimal survivability can be achieved through an integration of susceptibility and vulnerability reduction (hit survival) techniques. Vulnerability reduction techniques are particularly necessary during take-off and landing when restrictions to tactics and countermeasures are in-place. Vulnerability reduction techniques are also particularly important for commercial aircraft in that the use of flares and rapid G-maneuvers is not appropriate.

Emphasis of the proposed program will be on developing cost effective and low-weight vulnerability reduction techniques for transport aircraft encountering IR MANPADS threats. However, solutions may prove applicable to all aircraft and threats encountered. Low risk example solutions for military-commercial aircraft application include relocating critical components away from hot-spots, locally hardening fixed critical components, moving hot-spots to less vulnerable locations, using sacrificial structure, and improved fire suppression techniques. While each example is expected to enhance transport aircraft survivability, proposed vulnerability reduction techniques need prioritized based on various orders of merit (i.e., cost, weight, effectiveness, aircraft type limitations, retrofitability, implementation time, etc.). Highly ranked concepts will be evaluated using modeling and simulation to identify probabilities-of-effectiveness as compared to unprotected aircraft systems. The most promising vulnerability reduction concepts will be transitioned into an advanced development stage of the program. Modeling and ground-based vulnerability testing will be performed to determine the success of competing systems. Passing systems will be flight tested aboard selected military and commercial aircraft. Successful vulnerability reduction techniques will be presented to SPO Program Managers, the FAA, and NTSB for endorsement and incorporation into design guidelines.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $2.2M

ESTIMATED PROGRAM DURATION: 36 months

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00-VA-02

TITLE: AIR VEHICLE SUSTAINMENT

OBJECTIVE: Develop air vehicle technologies to sustain operational aircraft in a climate of longer service lives than originally planned and expanded operational roles. Military benefits are increased reliability, decreased operations and support costs, decreased risk of aircraft loss and increased availability. These technologies will apply to commercial aircraft operators and will also decrease operations costs and decrease risk of aircraft loss.

DESCRIPTION: The sustainment of existing aircraft provides challenges in a climate of spiraling operating costs and fewer replacements. The goal of this topic is to provide innovative solutions to enable operation with reduced costs and/or expanded capabilities. The emphasis should be in technologies which provide measurable gains in reliability and reductions in maintenance costs. Areas of focus could include structural integrity, repair/life enhancement, survivability/vulnerability, actuation and control, subsystems and aero configurations. Efforts should identify the baseline from which to measure the technology payoff.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $0.35M

ESTIMATED PROGRAM DURATION: 24 months

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00-VA-04

TITLE: REVOLUTIONARY TECHNOLOGIES FOR ADVANCED UAVs

OBJECTIVE: The Air Force is interested in aggressively pursuing emerging technologies to develop, field, and operate UAV solutions for applicable military roles across the spectrum of warfare to meet validated needs within specific mission areas based on cost, capability, reliability and suitability. Consistent with these objectives, the air vehicles directorate is interested in proposals for technology development which demonstrate revolutionary potential to cut cost, weight or increase performance. Candidate technologies include: Automated Flight Control Systems, Autonomous Aerial Refueling, Flexible Structures, Low-cost Composite Technology, Multifunctional Integrated Structures and Subsystems, Active Flow Control as well as Preliminary Design Tools for Advanced Technologies

DUAL USE APPLICATION: Uninhabited Air Vehicles have many commercial applications. Mail delivery, automated pipeline monitoring, drug enforcement and border control are but a few examples of the potential commercial uses. In addition, the revolutionary technologies of interest to the Air Vehicles Directorate also have dual use potential. Automated flight control has application to military and commercial UAVs in operations in mixed manned and unmanned air space and to general aviation in terms of reducing pilot work. Autonomous refueling can reduce control-related accidents as well as greatly enhance UAV endurance and range. Flexible and adaptive structures technology can extend the range and reduce maintenance costs for military and commercial high speed transports. Also, increased application of microprocessor technology in smart commodity products will also benefit from this technology by allowing embedding of electronic chips, wiring, power and other devices. Low Cost Composite Technologies and multifunctional integrated Structures and Subsystems have a wide variety of applications in commercial aviation and transportation vehicles where cost and weight are extremely critical for commercial viability. Active flow control technology can reduce drag and wheel well noise on military and commercial transports, Preliminary design tools can increase the effectiveness of all these technologies as these technologies come together in military and commercial products.

DESCRIPTION: The technologies described above offer revolutionary potential in their application to a UAV. Specific goals for programs developed from this solicitation in the flight systems area automated terminal maneuvering techniques for UAV safety and effectiveness, control applications criteria for mixed manned/unmanned airspace and the development of a safe, adverse weather/automated refueling system. Structures technology goals include preliminary and detail design and component testing as required. Subsystems must be designed to dissipate aggressive internal thermal loads. Active flow control goals are to demonstrate the payoff of this technology in terms of cost and performance on potential UAV configurations or subsystems. Products of tool development programs would be the validated software packages.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $1.55M

ESTIMATED PROGRAM DURATION: 30 Months

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00-VS-02

TITLE: SPACECRAFT MULTIFUNCTIONAL STRUCTURES TECHNOLOGIES

OBJECTIVE: Develop advanced primary and secondary structure technologies for weight and cost reduction in next generation commercial and defense spacecraft.

DESCRIPTION: Growing cost restrictions on advanced military, as well as commercial, space systems demand greater efficiency in spacecraft subsystems to provide higher payload mass fractions. Spacecraft structures have typically been viewed as essential but unproductive components of satellites. Developing technologies now provide the opportunity to revolutionize the efficiency of spacecraft structures and provide necessary weight savings for next generation systems. Current concepts ranging from low cost, lightweight composite fasteners to embedded electrical wiring offer distinct benefits. A focused development of one or two of these high risk, high payoff concepts could have a significant impact on future military and commercial space systems.

Technologies that could be considered include: multifunctional structures that integrate mechanical, thermal, radiation shielding and even electrical functions into a single entity; polyimide-covered panels with embedded copper traces or fiber optics for light weight power routing and data distribution; a bus-less satellite in which all spacecraft and some payload elements would be integral to an essential element such as a solar panel or an antenna structure; and the concept of using composite fibers as integral electrical conductors, eliminating the need for harnesses. Each of these technologies, while having potential weight and/or cost benefits, currently has significant uncertainties and technical challenges that require a focused development and demonstration program.

APPROACH:

Phase I: Conduct a critical assessment of promising structures/materials technologies relative to both the state-of-the-art and other, higher risk innovative concepts. Identify the potential impact on critical parameters such as weight, cost, and reliability. Delineate primary technical challenges facing various technologies, and assess the feasibility and timeline necessary for practical application. Select concepts for further development and demonstration. The primary result of Phase I shall be a well defined Phase II development and demonstration plan for a technology with potentially high payoff for military space communication systems.

Phase II: Demonstrate the feasibility of the technology(s) identified in Phase I. Tasks shall include, but not be limited to, a detailed analysis of the performance of the technology, detailed demonstration of key technical parameters (at a subscale level) to mutually agreed upon (Air Force and contractor) specifications and documented analysis of performance, manufacturability and cost.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $0.7M

ESTIMATED PROGRAM DURATION: 36 months

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DISTRIBUTED MISSION TRAINING

00-ML-03

TITLE: WEB-BASED 'VIRTUAL' MATERIALS PROTOTYPING

OBJECTIVE: The objective of this effort is to develop a materials prototyping environment to support a web-based community in sharing customer-supplier information that enables improved responsiveness in analyzing total ownership cost versus performance. Since DoD represents a relatively small market with uniquely demanding performance requirements, a need exists to establish a means of prototyping unique materials and their respective interface constraints, requirements, design and processing knowledge for devices and/or subsystems. The military benefit and commercial opportunity is a web-based prototyping environment to enable the equivalent of Moore's Law for materials engineering where, in lieu of every 1.5 years, over the course of a nominal 3 years we are able to double the speed and halve the cost in the design of thin-films for detection, energy production, life extension, etc..

DESCRIPTION: Department of Defense 'Integrated Product-Process Design' (IPPD) Initiatives have established a clear focus toward reducing cost and improving responsiveness. Notwithstanding these initiatives, more fundamental collaborative design activities such as 'virtual' prototyping of new materials: thin-films, coatings, micro-electro-mechanical systems (MEMS), etc. are constrained by poor cost-to-process-to-geometry-to-function coupling and the inability to compare conventional with new, more compact and/or reduced scale designs. Materials and interface-specific constraints, where adhesion, nano-scale toughness, oxidation resistance, lattice-mismatch, crystal structure, roughness, grain size, texture etc., are critical to functional performance, are an emerging area of design specification that requires a team effort with designers representing multiple disciplines. But interaction between designers is limited by their use of application—and often platform—specific design systems. With the advent of conformal electo-optical devices and gradient material systems and interfacial boundaries for both bulk and thin-films, new 'more atomic-scale' levels of materials design and analyses will be required where both properties and processes must be evaluated. These design tasks are typically performed independently, lacking timely coordination and thus, resulting in a collision of unrelated design criteria, which results in a "take what you get" design mentality.

ESTIMATED FEDERAL FUNDING CONTRIBUTION: $1.32M

ESTIMATED PROGRAM DURATION: 24 months

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